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(71)Applicant : SHOWA ELECTRIC WIRE & CABLE CO LTD

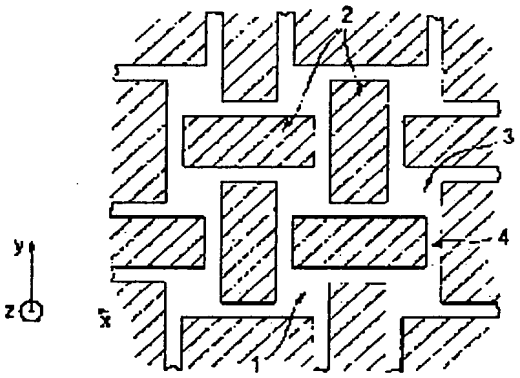
(72)Inventor : NORO HARUTO
SAKAMOTO NAOSHI

## (54) PHOTONIC CRYSTAL STRUCTURE

(57)Abstract:

PROBLEM TO BE SOLVED: To obtain a wide photonic band gap in a frequency region common to polarized light having no electric field component in the Z-axis direction and polarized light having no magnetic field component in the Z-axis direction.

SOLUTION: This photonic crystal structure consists of a plurality of rectangular rods 2 having a uniform side length in the Z-axis direction corresponding to the wavelength of light and arranged as alternately rotated by 90 degrees from one another, and of the surrounding dielectric material which has a greatly different dielectric const. from that of the rectangular rods and which is disposed to surround the rectangular rods. Thereby, the obtained structure has characteristics to suppress propagation of light waves in the frequency region common to polarized light having no electric field component in the Z-axis direction and polarized light having no magnetic field component in the Z-axis direction.

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CLAIMS

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[Claim(s)]
[Claim 1] It is the photograph nick crystal structure which it is formed in the direction perpendicular to a periodic side with two sorts of dielectrics with which uniform dielectric constants differ, and the rectangle rod concerned which one dielectrics are two or more rectangle rods which have the side length equivalent to light wave length, and adjoins rotates 90 degrees mutually, is arranged, and is characterized by preparing the dielectric of another side in the perimeter of said rectangle rod.
[Claim 2] The photograph nick crystal structure according to claim 1 characterized by having the property which controls propagation of a light wave in a common frequency domain to the polarization without the polarization and magnetic field component which do not have an electric-field component in the direction perpendicular to a periodic side.
[Claim 3] It is the photograph nick crystal structure which it is formed in the direction perpendicular to a periodic side with two sorts of dielectrics with which uniform dielectric constants differ, and the ellipse form rod concerned which one dielectrics are two or more ellipse form rods which have the axial length equivalent to light wave length, and adjoins rotates 90 degrees mutually, is arranged, and is characterized by preparing the dielectric of another side in the perimeter of said ellipse form rod.
[Claim 4] The photograph nick crystal structure according to claim 3 characterized by having the property which controls propagation of a light wave in a common frequency domain to the polarization without the polarization and magnetic field component which do not have an electric-field component in the direction perpendicular to a periodic side.

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## DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the photograph nick crystal structure which forms the photograph nick band gap which forbids propagation of the light wave of a specific wavelength field.
[0002]
[Description of the Prior Art] If a dielectric constant is periodically changed from the former a lot in wavelength, the frequency domain in which an electromagnetic wave cannot have the mode of a proper, i.e., a photograph nick band gap, is formed, and the photograph nick crystal structure by which propagation of light with the photon energy equivalent to a photograph nick band gap is controlled is known. If the defect to which the dielectric constant was changed artificially is introduced into such a photograph nick crystal structure, permission level will be formed into a photograph nick band gap, and the radiation with the photon energy equivalent to the level of only light will be attained. The photograph nick crystal structure is the most promising ingredient for controlling an electromagnetic wave, and the utilization in respect of [, such as single wavelength light emitting diode, and non-threshold laser, a filter a high density optical integrated circuit, ] application is expected.
[0003] As such a photograph nick crystal, two-dimensional A direction perpendicular to the periodic side periodically arranged [ the shape of a tetragonal lattice ] to the perimeter dielectric 10 with dielectric constant epsilonb which is greatly different from dielectric constant epsilona in the circular rod 11 with dielectric constant epsilona as shown in drawing 5 As shown in the thing of structure uniform for (Z shaft orientations being called hereafter), or drawing 6 , the thing of uniform structure etc. was in the Z-axis periodically arranged in the shape of a tetragonal lattice at the perimeter dielectric 20 with dielectric constant epsilonb which is greatly different from dielectric constant epsilona in the square rod 21 with dielectric constant epsilona.
[0004]
[Problem(s) to be Solved by the Invention] However, although a large photograph nick band gap exists like drawing 5 in such a two-dimensional photograph nick crystal by the polarization which does not have a magnetic field component in Z shaft orientations, and the so-called TM mode when the circular rod 11 has been periodically arranged in the shape of a tetragonal lattice the polarization which does not have an electric-field component in Z shaft orientations, and the so-called TE mode -- a photograph nick band gap -- the dielectric constant ratio of the circular rod 11 and the perimeter dielectric 10, and a filling factor (the rate that the field where a dielectric constant is high occupies -- ) etc. -- it was the thing in which a photograph nick band gap exists slightly according to conditions and which is not boiled too much.
[0005] On the other hand, like drawing 6 , when the square rod 21 had been periodically arranged in the shape of a tetragonal lattice, although the large photograph nick band gap existed by the TE mode conversely, the photograph nick band gap was narrow [ in the TM mode / by conditions such as a dielectric constant ratio and a filling factor, ] in the case of the circular rod 11. For example, constitute the square rod 21 from Ayr, and are the thing of the dielectric constant ratio 8.9 to Ayr, and a perimeter dielectric is constituted. It is referred to as epsilona=1, 0, and epsilonb=8.9, and namely, the density of states of the light wave by which TE when being referred to as a and TM both

polarization were calculated in the lattice constant of a tetragonal lattice a filling factor 30% As shown in drawing 7 , in the TE mode and the TM mode, the density of states of light had rivaled in almost all frequency domains, and the frequency domain whose photograph nick band gap corresponds was not accepted.

[0006] In the structure where the dielectric spot 12 of the perimeter dielectric 10 with which this was surrounded by four adjoining circular rods 11 has been periodically arranged in a certain amount of magnitude Possibility that a photograph nick band gap will be made to TM polarization is high. In the structure where the narrow dielectric vein 22 of the perimeter dielectric 20 surrounded among four adjoining square rods 21 has been arranged periodically, it is thought that it is because possibility that a photograph nick band gap will be made to TE polarization is high. Although this was made clear also from theoretical count of electromagnetic wave propagation, TE and the photograph nick crystal structure which has a broad photograph nick band gap in TM both polarization in a common frequency domain did not exist.

[0007] This invention is made in order to cancel the above-mentioned fault, and the purpose of this invention offers the two-dimensional photograph nick crystal structure of the shape of TE and a tetragonal lattice which has a broad photograph nick band gap to TM both polarization in a common frequency domain.

[0008]

[The means for solving invention] The photograph nick crystal structure of this invention is formed with two sorts of dielectrics with which uniform dielectric constants differ in Z shaft orientations in order to attain the above-mentioned purpose. One dielectrics are two or more rectangle rods which have the side length equivalent to light wave length. The adjoining rectangle rod concerned rotates 90 degrees mutually, and is arranged, and the dielectric of another side is prepared in the perimeter of a rectangle rod. Preferably It has the property which controls propagation of a light wave in a common frequency domain to the polarization without the polarization and magnetic field component which do not have an electric-field component in Z shaft orientations.

[0009] Moreover, the photograph nick crystal structure of this invention is formed with two sorts of dielectrics with which uniform dielectric constants differ in Z shaft orientations. One dielectrics are two or more ellipse form rods which have the axial length equivalent to light wave length. The adjoining ellipse form rod concerned rotates 90 degrees mutually, and is arranged, and the dielectric of another side is prepared in the perimeter of an ellipse form rod. Preferably It has the property which controls propagation of a light wave in a common frequency domain to the polarization without the polarization and magnetic field component which do not have an electric-field component in Z shaft orientations.

[0010] Since it constituted from a perimeter dielectric which the photograph nick crystal structure of the invention in this application rotates by turns two or more rectangle rods which have the side length equivalent to light wave length 90 degrees, and is arranged, and these differ from a dielectric constant greatly, and is prepared in these perimeters, A perimeter dielectric serves as the configuration where the part (vein) of a narrow area formed in the part (spot) of a large area in which a long side is formed of a part longer than a shorter side, and the part which a shorter side and a long side adjoin continued by turns. For this reason, propagation of a light wave can be controlled in a common frequency domain to the polarization without the polarization and magnetic field component which do not have an electric-field component in Z shaft orientations.

[0011] Moreover, since it constituted from a perimeter dielectric which the ellipse form rod which has the axial length who is equivalent to light wave length similarly is rotated 90 degrees by turns, it arranges, and these differ from a dielectric constant greatly, and is prepared in these perimeters, A perimeter dielectric serves as the configuration where the part (spot) of a large area in which a major axis is formed of a part longer than a minor axis, and the part (vein) of a narrow area formed of the crowning (a part for the point of the direction of a major axis) of an ellipse and the abdomen (a part for the point of the direction of a minor axis) of an ellipse continued by turns. For this reason, propagation of a light wave can be controlled in a common frequency domain to the polarization without the polarization and magnetic field component which do not have an electric-field component in Z shaft orientations.

[0012]

[Embodiment of the Invention] The desirable operation gestalt which applied the photograph nick crystal structure of this invention is explained with reference to a drawing. The photograph nick crystal structure of this invention consists of perimeter dielectrics 1 which are prepared in the perimeter of two or more rectangle rods 2 which have dielectric constant epsilona, and the rectangle rod 2, and have dielectric constant epsilonb, as shown in drawing 1 .

[0013] The rectangle rod 2 rotates 90 degrees to mutual [ adjoining / four rectangle rods 2 and mutual ], and is arranged. That is, what rotated the rectangle rod 2 90 degrees is arranged alternately. The long side of the rectangle rod 2 and a shorter side have the approximated die length with light wave length, and the rectangle rod 2 has the almost same cross section as the cross section of the conventional square rod 12.

[0014] Since the perimeter dielectric 1 is formed in the perimeter of such a rectangle rod 2, as shown in drawing 1 , it serves as a configuration which has the hybrid construction with which the dielectric vein 4 of the dielectric spot 3 in which the long side of the rectangle rod 2 is formed of a part longer than a shorter side, and the pinched narrow part was connected continuously by turns. As for the die length of the long side of the rectangle rod 2 of such the photograph nick crystal structure, and a shorter side, it is desirable that the predetermined ratio [ comparatively as opposed to a long side ] of a shorter side is a rate centering on 0.5.

[0015] Moreover, as other photograph nick crystal structures, as shown in drawing 2 , it consists of perimeter dielectrics 5 which are prepared in the perimeter of two or more ellipse form rods 6 which have dielectric constant epsilona, and the ellipse form rod 6, and have dielectric constant epsilonb. The ellipse form rod 6 rotates 90 degrees to mutual [ adjoining / four ellipse form rods 6 and mutual ], and is arranged. That is, what rotated the ellipse form rod 6 90 degrees is arranged alternately. The major axis of the ellipse form rod 6 and a minor axis have the approximated die length with light wave length, and the ellipse form rod 6 has the almost same cross section as the cross section of the conventional circular rod 11.

[0016] Since the perimeter dielectric 5 is formed in the perimeter of such an ellipse form rod 6, as shown in drawing 2 , it serves as a configuration which has the hybrid construction with which the dielectric vein 8 of the dielectric spot 7 in which the major axis of the ellipse form rod 6 is formed of a part longer than a minor axis, and the pinched narrow part was connected continuously by turns. Moreover, as for the ratio of a minor axis to a major axis, also in the ellipse form rod 6, it is desirable to center the same on 0.5.

[0017] In order to manufacture the photograph nick crystal structure which has such hybrid construction, the semi-conductor membrane formation approach can be used. Masks, such as Cr, can be made the substrate of aluminum2O3, Si, and SiO2 grade, the pattern of a rectangle or an ellipse form can be imprinted, and it can manufacture by forming the Ayr pattern in a substrate by etching. Moreover, a rectangle rod etc. cannot be made into depletion (Ayr), but can also be made into the thing of the desired quality of the material.

[0018] In the photograph nick crystal structure which has such hybrid construction, it has a photograph nick band gap to TE polarization, and a photograph nick band gap to TM polarization in a common frequency domain. A perfect band gap is generable with conditions, such as a dielectric constant ratio of the rectangle rod 2 or the ellipse form rod 6, and the perimeter dielectrics 1 and 5, and a filling factor, in the frequency domain common to TE polarization and TM polarization.

[0019] The result of having set the ratio of the shorter side of the rectangle rod 2 and a long side to 0.5, and having carried out theoretical count of the density of states of the light wave to TE polarization and TM polarization when making into a lattice constant a dielectric constant epsilona=1.0 of the rectangle Ayr rod 2, dielectric constant epsilonb=8.9 of the perimeter dielectric aluminum 2O3, and the rate, i.e., a filling factor, that a perimeter dielectric occupies, 30% as an example of this invention became what is shown in drawing 3 . It turns out that the photograph nick band gap with the density of states of a light wave common to zero, i.e., both the modes, is generated by the 0.32 to normalized-radiam-frequency 0.34 neighborhood so that clearly from drawing 3 .

[0020] Moreover, change of the band gap width of face when seting constant the cross-sectional area of the rectangle Ayr rod 2, having used the lattice constant a of the rectangle Ayr rod 2 as 0.5 micrometers, and changing the ratio of a shorter side and a long side is as being shown in drawing 4 . When the cross section of the rectangle Ayr rod 2 is fixed, it turns out that the ratio of a shorter side

to a long side is [ the width of face of the band gap of a frequency domain common to TE polarization and TM polarization ] max to 0.5, so that clearly also from drawing 4 .
[0021] The above explanation is about one example of the invention in this application, and the invention in this application is not limited to this, but can apply suitably the thing of the well-known quality of the material which has various dielectric constants. Moreover, not only two-dimensional structure but this two-dimensional structure can also be made into the thing of predetermined thickness.
[0022]
[Effect of the Invention] According to the photograph nick crystal structure of this invention, it considers as the arrangement which rotated the rectangle rod or the ellipse form rod 90 degrees by turns, and since it constituted from a perimeter dielectric which has the dielectric constant from which these and a dielectric constant differ greatly, in the frequency domain which is common to TE polarization and TM polarization, a broad photograph nick band gap can be obtained, so that clearly also from the above explanation. For this reason, it can use suitable for semiconductor laser, a filter, etc.

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## DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The explanatory view showing 1 operation gestalt of the photograph nick crystal structure of this invention.
[Drawing 2] The explanatory view showing other operation gestalten of this invention.
[Drawing 3] The explanatory view of the property of the photograph nick crystal structure of this invention.
[Drawing 4] The explanatory view of the property of the photograph nick crystal structure of this invention.
[Drawing 5] The explanatory view of the conventional example.
[Drawing 6] The explanatory view of the conventional example.
[Drawing 7] The explanatory view of the property of the conventional example.
[Description of Notations]
1 5 ..... Perimeter dielectric
2 ..... Rectangle rod
6 ..... Ellipse form rod

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DRAWINGS

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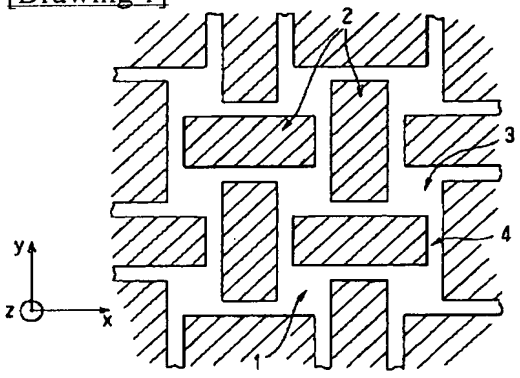
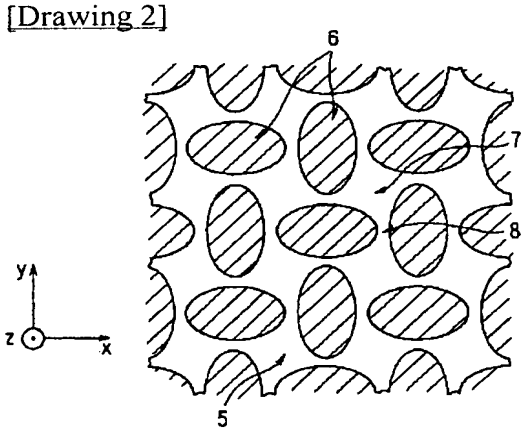
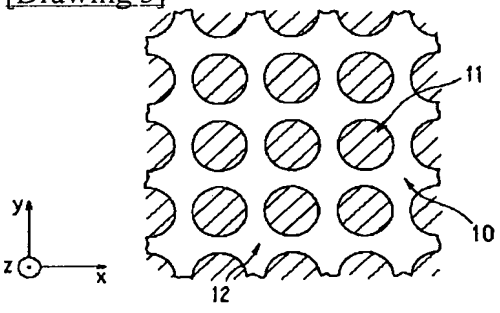
[Drawing 1]



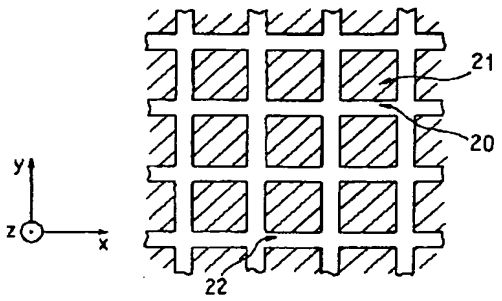

[Drawing 2]



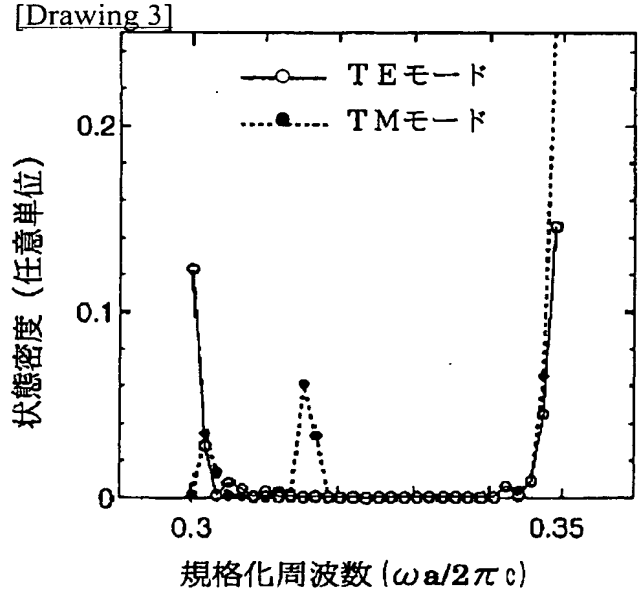

[Drawing 5]



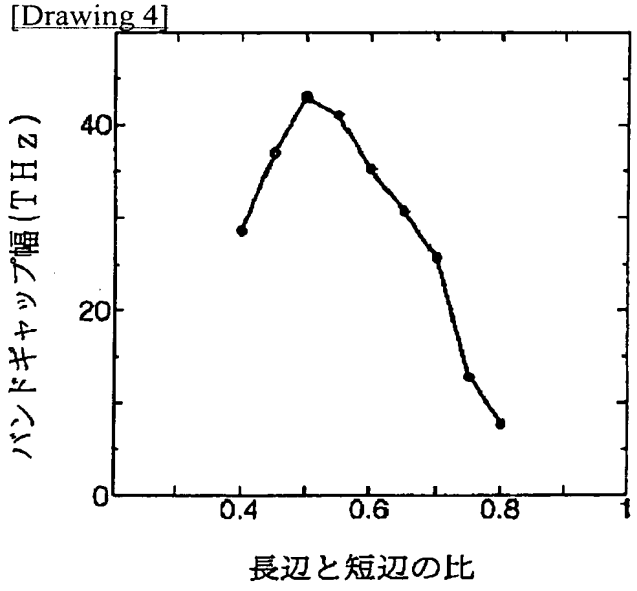

[Drawing 6]



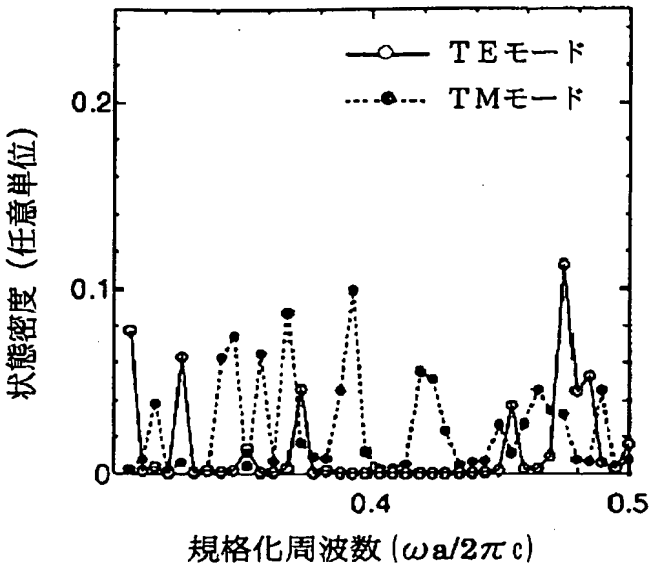

[Drawing 3]




[Drawing 4]




[Drawing 7]

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(71)出願人　000002255
昭和電線電纜株式会社
神奈川県川崎市川崎区小田栄２丁目１番１号

(72)発明者　野呂　治人
川崎市川崎区小田栄２丁目１番１号　昭和電線電纜株式会社内

(72)発明者　坂本　直志
川崎市川崎区小田栄２丁目１番１号　昭和電線電纜株式会社内

(74)代理人　100077584
弁理士　守谷　一雄

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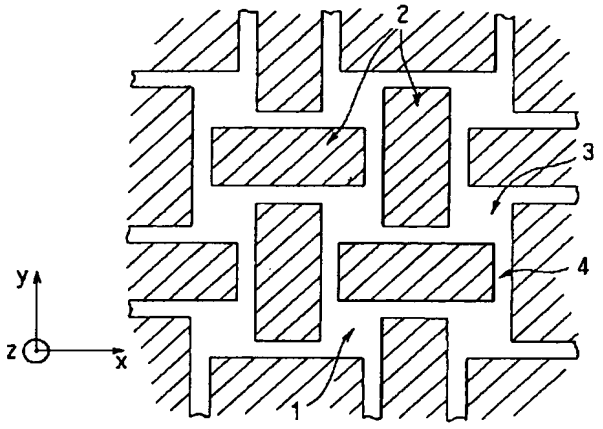
(54)【発明の名称】フォトニック結晶構造

(57)【要約】
【課題】Ｚ軸方向に電場成分をもたない偏光及び磁場成分をもたない偏光に対して共通する周波数領域で幅広いフォトニック・バンドギャップを得る。
【解決手段】フォトニック結晶構造は、Ｚ軸方向に一様な光波長に相当する辺長を有する複数の長方形ロッド２が相互に９０度回転されて配置され、この長方形ロッドの誘電率と大きく異なる誘電率を有し長方形ロッドの周囲に設けられるＺ軸方向に一様な周囲誘電体１によって構成される。このため、Ｚ軸方向に電場成分を持たない偏光及び磁場成分を持たない偏光に対して共通な周波数領域で光波の伝播を抑制する特性を有するものとすることができる。



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【特許請求の範囲】

【請求項１】周期面に垂直な方向に一様な誘電率の異なる２種の誘電体で形成され、一方の誘電体は光波長に相当する辺長を有する複数の長方形ロッドであって、隣接する当該長方形ロッドが相互に９０度回転されて配置され、他方の誘電体は前記長方形ロッドの周囲に設けられることを特徴とするフォトニック結晶構造。

【請求項２】周期面に垂直な方向に電場成分を持たない偏光及び磁場成分を持たない偏光に対して共通な周波数領域で光波の伝播を抑制する特性を有することを特徴とする請求項１記載のフォトニック結晶構造。

【請求項３】周期面に垂直な方向に一様な誘電率の異なる２種の誘電体で形成され、一方の誘電体は光波長に相当する軸長を有する複数の楕円形ロッドであって、隣接する当該楕円形ロッドが相互に９０度回転されて配置され、他方の誘電体は前記楕円形ロッドの周囲に設けられることを特徴とするフォトニック結晶構造。

【請求項４】周期面に垂直な方向に電場成分を持たない偏光及び磁場成分を持たない偏光に対して共通な周波数領域で光波の伝播を抑制する特性を有することを特徴とする請求項３記載のフォトニック結晶構造。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、特定の波長領域の光波の伝播を禁じるフォトニックバンドギャップを形成するフォトニック結晶構造に関する。

【０００２】

【従来の技術】従来から、誘電率を波長単位で周期的に大きく変化させると、電磁波が固有のモードを持てない周波数領域、即ちフォトニック・バンドギャップが形成され、フォトニック・バンドギャップに相当する光子エネルギーを持つ光の伝播が抑制されるフォトニック結晶構造が知られている。このようなフォトニック結晶構造に、人為的に誘電率を変化させた欠陥を導入すると、フォトニック・バンドギャップ中に許容準位が形成され、その準位に相当する光子エネルギーをもつ光のみの放射が可能となる。フォトニック結晶構造は、電磁波を制御するための最も有望な材料であり、単一波長発光ダイオードや無閾値レーザ、フィルター及び高密度光集積回路などの応用面での実用化が期待されるものである。

【０００３】このようなフォトニック結晶としては、２次元的には、図５に示すように、誘電率εａをもつ円形ロッド１１を、誘電率εａと大きく異なる誘電率εｂをもつ周囲誘電体１０に正方格子状に周期的に配置した周期面に垂直な方向（以下、Ｚ軸方向と称す）に一様な構造のもの、あるいは、図６に示すように、誘電率εａをもつ正方形ロッド２１を、誘電率εａと大きく異なる誘電率εｂをもつ周囲誘電体２０に正方格子状に周期的に配置されたＺ軸に一様な構造のもの等があった。

【０００４】

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【発明が解決しようとする課題】しかしながら、このような２次元フォトニック結晶においては、図５のように、円形ロッド１１を正方格子状に周期的に配置した場合、Ｚ軸方向に磁場成分を持たない偏光、所謂ＴＭモードでは、広いフォトニック・バンドギャップが存在するが、Ｚ軸方向に電場成分を持たない偏光、所謂ＴＥモードでは、フォトニック・バンドギャップは円形ロッド１１と周囲誘電体１０との誘電率比や充填率（誘電率の高い領域が占める割合。）等の条件により、フォトニック・バンドギャップは僅かに存在するに過ぎないものであった。

【０００５】一方、図６のように、正方形ロッド２１を正方格子状に周期的に配置した場合は、円形ロッド１１の場合とは逆に、ＴＥモードでは、広いフォトニック・バンドギャップが存在するが、ＴＭモードでは、誘電率比や充填率等の条件により、フォトニック・バンドギャップは狭いものであった。例えば、正方形ロッド２１をエアーで構成し、周囲誘電体をエアーに対する誘電率比８．９のもので構成し、即ちεａ＝１・０、εｂ＝８．９とし、充填率を３０％、正方格子の格子定数をａとしたときのＴＥ、ＴＭ両偏光の計算された光波の状態密度は、図７に示すように、ＴＥモードとＴＭモードにおいて光の状態密度が殆どの周波数領域で拮抗しており、フォトニック・バンドギャップが一致する周波数領域は認められなかった。

【０００６】これは、４つの隣接する円形ロッド１１に囲まれた周囲誘電体１０の誘電体スポット１２がある程度の大きさで周期的に配置された構造においては、ＴＭ偏光に対してフォトニック・バンドギャップのできる可能性が高く、４つの隣接する正方形ロッド２１の間に囲まれた周囲誘電体２０の狭い誘電体ベイン２２が周期的に配置された構造においては、ＴＥ偏光に対してフォトニック・バンドギャップのできる可能性が高いためであると考えられる。このことは、電磁波伝播の理論計算からも明らかにされていたが、ＴＥ、ＴＭ両偏光において共通の周波数領域で幅広いフォトニック・バンドギャップを有するフォトニック結晶構造は存在しなかった。

【０００７】本発明は上記欠点を解消するためになされたものであって、本発明の目的は、ＴＥ、ＴＭ両偏光に対して共通の周波数領域で幅広いフォトニック・バンドギャップを持つ正方格子状の２次元フォトニック結晶構造を提供するものである。

【０００８】

【発明を解決するための手段】本発明のフォトニック結晶構造は上記目的を達成するため、Ｚ軸方向に一様な誘電率の異なる２種の誘電体で形成され、一方の誘電体は光波長に相当する辺長を有する複数の長方形ロッドであって、隣接する当該長方形ロッドが相互に９０度回転されて配置され、他方の誘電体は長方形ロッドの周囲に設けられ、好ましくは、Ｚ軸方向に電場成分を持たない偏

光及び磁場成分を持たない偏光に対して共通な周波数領域で光波の伝播を抑制する特性を有するものである。

【０００９】また、本発明のフォトニック結晶構造は、Ｚ軸方向に一様な誘電率の異なる２種の誘電体で形成され、一方の誘電体は光波長に相当する軸長を有する複数の楕円形ロッドであって、隣接する当該楕円形ロッドが相互に９０度回転されて配置され、他方の誘電体は楕円形ロッドの周囲に設けられ、好ましくは、Ｚ軸方向に電場成分を持たない偏光及び磁場成分を持たない偏光に対して共通な周波数領域で光波の伝播を抑制する特性を有するものである。

【００１０】本願発明のフォトニック結晶構造は、光波長に相当する辺長を有する複数の長方形ロッドを交互に９０度回転させて配置し、これらと誘電率が大きく異なりこれらの周囲に設けられる周囲誘電体とで構成したため、周囲誘電体は、長辺が短辺より長い部分によって形成される大きい面積の部分（スポット）と、短辺と長辺が隣接する部分で形成される狭い面積の部分（ベイン）が交互に連続した形状となる。このため、Ｚ軸方向に電場成分を持たない偏光及び磁場成分を持たない偏光に対して共通な周波数領域で光波の伝播を抑制することができる。

【００１１】また、同様に光波長に相当する軸長を有する楕円形ロッドを交互に９０度回転させて配置し、これらと誘電率が大きく異なりこれらの周囲に設けられる周囲誘電体とで構成したため、周囲誘電体は、長軸が短軸より長い部分によって形成される大きい面積の部分（スポット）と、楕円の頂部（長軸方向の先端部分）と楕円の腹部（短軸方向の先端部分）によって形成される狭い面積の部分（ベイン）が交互に連続した形状となる。このため、Ｚ軸方向に電場成分を持たない偏光及び磁場成分を持たない偏光に対して共通な周波数領域で光波の伝播を抑制することができる。

【００１２】

【発明の実施の形態】本発明のフォトニック結晶構造を適用した好ましい実施形態について図面を参照して説明する。本発明のフォトニック結晶構造は、図１に示すように、誘電率εａを有する複数の長方形ロッド２と、長方形ロッド２の周囲に設けられ誘電率εｂを有する周囲誘電体１で構成される。

【００１３】長方形ロッド２は隣接する４つの長方形ロッド２と相互に９０度回転されて配置される。即ち、長方形ロッド２を９０度回転させたものを１つおきに配置したものである。長方形ロッド２の長辺、短辺は光波長と近似した長さを有し、且つ、長方形ロッド２は従来の正方形ロッド１２の断面積とほぼ同一の断面積を有する。

【００１４】周囲誘電体１は、このような長方形ロッド２の周囲に設けられるため、図１に示すように、長方形ロッド２の長辺が短辺より長い部分によって形成される誘電体スポット３と、短辺と長辺によって挟まれた狭い部分の誘電体ベイン４が交互に連続的につながったハイブリッド構造を有する形状となっている。このようなフォトニック結晶構造の長方形ロッド２の長辺と短辺との長さは所定の割合、長辺に対する短辺の比が０．５を中心とした割合であることが好ましい。



【００１５】また、他のフォトニック結晶構造として、図２に示すように、誘電率εａを有する複数の楕円形ロッド６と、楕円形ロッド６の周囲に設けられ誘電率εｂを有する周囲誘電体５で構成される。楕円形ロッド６は隣接する４つの楕円形ロッド６と相互に９０度回転されて配置される。即ち、楕円形ロッド６を９０度回転させたものを１つおきに配置したものである。楕円形ロッド６の長軸、短軸は光波長と近似した長さを有し、且つ、楕円形ロッド６は従来の円形ロッド１１の断面積とほぼ同一の断面積を有する。

【００１６】周囲誘電体５は、このような楕円形ロッド６の周囲に設けられるため、図２に示すように、楕円形ロッド６の長軸が短軸より長い部分によって形成される誘電体スポット７と、楕円の頂部と復部によって挟まれた狭い部分の誘電体ベイン８が交互に連続的につながったハイブリッド構造を有する形状となっている。また、楕円形ロッド６においても、長軸に対する短軸の比は同様に０．５を中心としたものであることが好ましい。

【００１７】このようなハイブリッド構造を有するフォトニック結晶構造を製造するには、半導体成膜方法を用いることができる。$Al_2O_3$、Ｓｉ、$SiO_2$等の基板にＣｒ等のマスクをして長方形あるいは楕円形のパターンを転写し、エッチングにより基板にエアーパターンを形成することにより製造することができる。また、長方形ロッド等も空乏（エアー）とせず所望の材質のものとすることもできる。

【００１８】このようなハイブリッド構造を有するフォトニック結晶構造においては、ＴＥ偏光に対するフォトニック・バンドギャップと、ＴＭ偏光に対するフォトニック・バンドギャップを共通する周波数領域において有するものである。長方形ロッド２または楕円形ロッド６と周囲誘電体１、５との誘電率比や充填率などの条件により、ＴＥ偏光とＴＭ偏光に共通する周波数領域で完全なバンドギャップを生成することができる。

【００１９】本発明の実施例として、長方形ロッド２の短辺と長辺との比を０．５とし、長方形エアーロッド２の誘電率εａ＝１．０、周囲誘電体$Al_2O_3$の誘電率εｂ＝８．９、周囲誘電体が占める割合、即ち充填率を３０％、格子定数ａとしたときのＴＥ偏光とＴＭ偏光に対する光波の状態密度を理論計算した結果は、図３に示すものとなった。図３から明らかなように、規格化周波数０．３２～０．３４付近に光波の状態密度がゼロ、即ち両モードに共通のフォトニック・バンドギャップが生成されていることがわかる。

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【００２０】また、長方形エアーロッド２の格子定数ａを０．５μｍとして、長方形エアーロッド２の断面積を一定として、短辺と長辺の比を変化させたときのバンドギャップ幅の変化は、図４に示すとおりである。図４からも明らかなように、長方形エアーロッド２の断面積が一定のとき、長辺に対する短辺の比が０．５に対して、ＴＥ偏光とＴＭ偏光に共通な周波数領域のバンドギャップの幅が最大であることがわかる。

【００２１】以上の説明は本願発明の一実施例についてであり、本願発明はこれに限定されず、種々の誘電率を有する公知の材質のものを好適に適用することができる。また、２次元構造に限らず、この２次元構造を所定の厚さのものとすることもできる。

【００２２】

【発明の効果】以上の説明からも明らかなように、本発明のフォトニック結晶構造によれば、長方形ロッドあるいは楕円形ロッドを交互に９０度回転させた配置とし、これらと誘電率が大きく異なる誘電率を有する周囲誘電体で構成したため、ＴＥ偏光、ＴＭ偏光に対して共通する周波数領域において幅広いフォトニック・バンドギャップを得ることができる。このため、半導体レーザ、フィルター等に好適に用いることができる。

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【図面の簡単な説明】

【図１】本発明のフォトニック結晶構造の一実施形態を示す説明図。

【図２】本発明の他の実施形態を示す説明図。

【図３】本発明のフォトニック結晶構造の特性の説明図。

【図４】本発明のフォトニック結晶構造の特性の説明図。

【図５】従来例の説明図。

【図６】従来例の説明図。

【図７】従来例の特性の説明図。

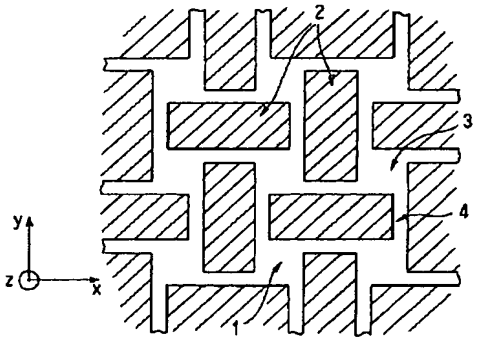
【符号の説明】

１、５・・・・・周囲誘電体

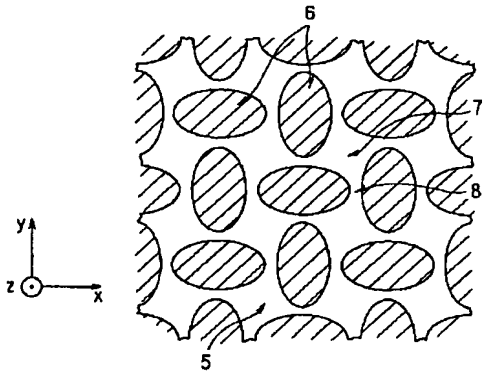
２・・・・・長方形ロッド

６・・・・・楕円形ロッド

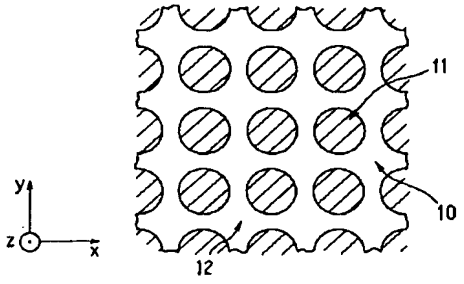
【図１】



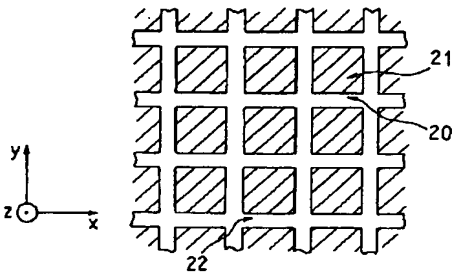

【図２】



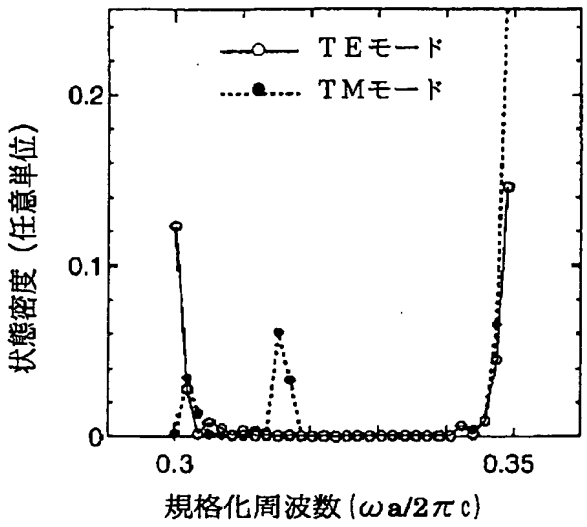

【図５】



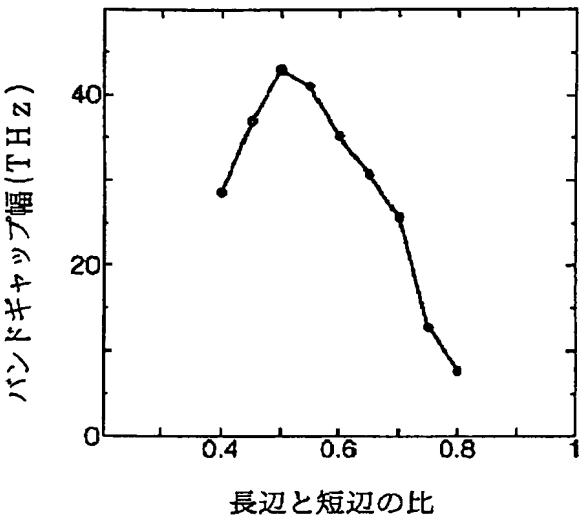

【図６】



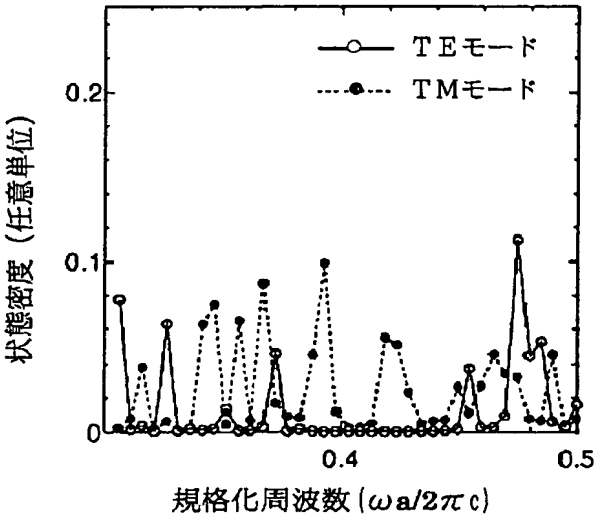
【図３】




【図４】




【図７】

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